# CO SELF-SHIELIDNG YIELDS OXYGEN WITH A $\delta^{17}O/\delta^{18}O$ RATIO OF UNITY

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**Introduction:** The CCAM line measured by Clayton et al. [1] has a slope of 0.94 and spans a range of roughly 40 ‰. The Yurimoto group extended this range with the discoveries of a chondrule with $\delta^{18}O$ ~ -75 ‰ [2] and of magnetite grains with $\delta^{18}O$ ~ +180 ‰ [3]. These materials define a solar system non-mass-dependent oxygen isotope line with a slope of 1.0 ± a few percent over a range of 255 ‰. The solar wind lies near but not on this line [4], presumably due to mass-dependent fractionation during solar wind acceleration. The line itself is believed to be a result of mixing of different solar system oxygen isotope reservoirs [5]. Self-shielding during CO photodissociation is the leading hypothesis for the $^{16}O$-poor end of the mixing line [6]. Model calculations [7-9] suggest that the self-shielding hypothesis is viable. However, recent CO photodissociation experiments have yielded O (in $CO_2$ product) with $\delta^{17}O/\delta^{18}O$ values ranging from 0.65 to 1.8 depending on the center wavelength of the synchrotron beam, and argue against CO self-shielding [10].

**Modeling of CO dissociation experiments:** Model simulations of the long-wavelength experiments in [10] have demonstrated that slopes ~ 1.4-1.9 are expected and result from self-shielding in $C^{18}O$ due to the high CO column densities used in the experiments [11]. Non-unity slopes occur when only a small fraction of CO is dissociated (~1 % of CO is dissociated in the experiments in [10]). As can be seen from figures 3a and 3b (at 107.6 and 105.2 nm, respectively) in [11], the $\delta^{17}O/\delta^{18}O$ ratio goes to unity. This occurs for ~ 10 % CO dissociation (at about $10^3$ seconds in [11]). (Note: the timescales of the simulations in [11] cannot be directly compared to [10]). The key point is that the CO isotopologue abundances adjust to the radiation field, and are predicted to yield a slope of unity when sufficient dissociation occurs. This appears to be consistent with the astrochemical model results of Visser et al. [12].

**A more general result:** To test the robustness of $\delta^{17}O/\delta^{18}O = 1$, and to account for possible isotopologue-dependent behavior in the strength of the CO bands and/or in the probability of dissociation, I ran the same model with widely varying band oscillator strengths (i.e. f-values, the quantum mechanical parameter that describes the strength of an electronic transition) and dissociation probabilities (the likelihood of curve-crossing). A factor of 10 increase in f-value for $C^{17}O$ relative to $C^{16}O$ and $C^{18}O$ (highly unlikely, in reality) yields slopes ~ 4 at early times, but again reaches 1.0 by ~ 10-20 % CO dissociation. I observed similar robustness to variations in dissociation probability. These results strongly support the CO self-shielding models.

**References:** [1] Clayton RN et al. 1973. *Science* 182, 485-488. [2] Kobayashi et al. 2003. *Geochem. J.* 37, 663-669. [3] Sakamoto N. et al. 2007. *Science* 317, 231-233. [4] McKeegan et al. 2010. Abstract # 2589, 41st LPSC. [5] Clayton RN & Mayeda TK. 1984. *EPSL 67*, 151-161. [6] Clayton RN 2002. *Nature* 415, 860-861. [7] Yurimoto H & Kuramoto K. 2004. *Science* 305, 1763-1766. [8] Lyons J & Young E. 2005. *Nature* 435, 317-320. [9] Lee et al. 2008. *MAPS* 43, 1351. [10] Chakraborty et al. 2008. *Science* 321, 1328. [11] Lyons et al. 2010, Abstract # 2651, 41st LPSC. [12] Visser R. et al. 2009. *Astron. & Astrophys.* 503, 323.